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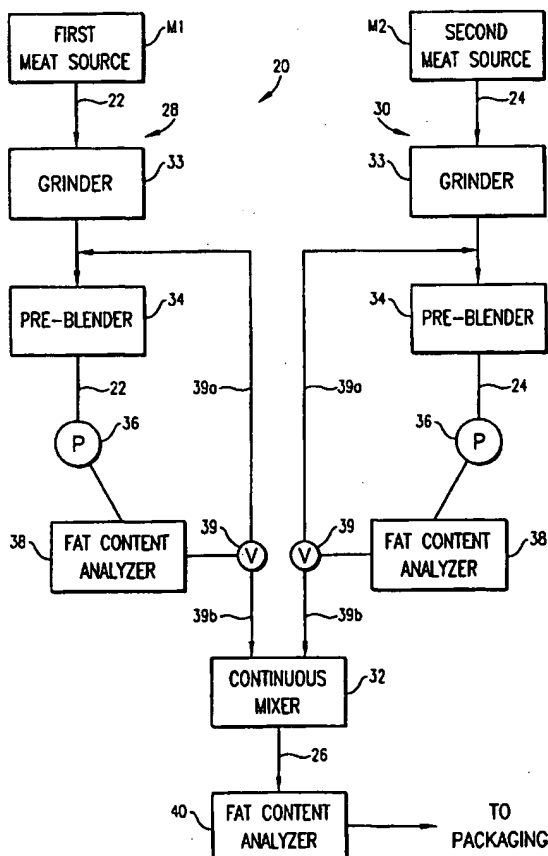
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(54) Title: **SYSTEM FOR HOMOGENEOUSLY MIXING PLURAL INCOMING PRODUCT STREAMS OF DIFFERENT COMPOSITIONS**



(57) Abstract: A continuous mixer (32) is disclosed which can be used for mixing of incoming product streams (22, 24) of different characteristics respectively to yield a final product stream (26) of predetermined, consistent characteristics. The mixer (32) includes an elongated housing (42) having a pair of product input ports (50, 52) and an output (64), with a pair of elongated, axially rotatable, mixing screws (44, 46) located within the housing (42). The screws (44, 46) include a series of outwardly projecting mixing elements (114) preferably of pyramidal design and arrayed in a helical pattern along the length of the screws (44, 46). The mixer (32) may be used in a processing system (20, 200) having individual product lines (28, 30, 204, 206) coupled to the mixer (32), and is especially useful for processing of incoming meat streams (22, 24) of different fat/lean ratios, to give a final comminuted output stream (26) of an intermediate and essentially constant fat/lean ratio. Preferably, the product lines (204, 206) are each equipped with a combine preblender and pumping device (202).

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-1-

SYSTEM FOR HOMOGENEOUSLY MIXING PLURAL INCOMING PRODUCT STREAMS OF DIFFERENT COMPOSITION

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BACKGROUND OF THE INVENTION

Field of the Invention

The present invention is broadly concerned with continuous mixing apparatus for the gentle yet thorough mixing of incoming product streams to yield a final product stream of predetermined desired characteristics. More particularly, the invention is concerned with such mixers, rotatable screws used therein, and methods of operation thereof, permitting the mixers to be used in overall systems preferably designed for the mixing of dissimilar characteristic incoming meat streams to produce a final product output stream of substantially constant characteristics. In addition, the mixer may also be used in the processing of substantially homogeneous products, such as in the mixing and stretching of cheese curd and the blending of fruits.

Description of the Prior Art

The meat industry is increasingly concerned with "case ready" meats which are prepared and packaged at a central processing facility, ready for display and sale at supermarkets. This marketing approach minimizes costly on-site labor at the supermarkets, leading to lower consumer prices. For example, comminuted meat products (e.g., hamburger) can be produced at a central facility and packaged in convenient sized consumer packages. One difficulty in this approach, however, lies in providing a consistent comminuted product having, e.g., the same fat/lean ratio. This is particularly difficult owing to the fact that starting meat sources may have very different fat/lean ratios, on a day-to-day or even hour-to-hour basis. Hence, a plant may be provided with meats having two widely divergent meat sources in terms of fat/lean ratios or other characteristics, and must be capable of accommodating such starting materials while still producing a comminuted product of substantially constant final properties.

Meat comminuting and mixing devices are in general well known, ranging from simple household sausage grinders to large industrial equipment. However, such prior devices cannot properly handle diverse starting products while still yielding consistent final products. In

-2-

addition, it is important in the mixing and handling of meat products that the meat not be comminuted and mixed to the point that it exhibits "smearing" or the loss of particulate appearance.

There is accordingly a need in the art for improved mixing apparatus and systems which can accept starting products of divergent and changing characteristics while nevertheless producing final products having predetermined, consistent properties; in the context of meat processing, such mixing apparatus must also accomplish these ends without significantly altering the desired meat appearance.

SUMMARY OF THE INVENTION

The present invention overcomes the problems outlined above, and provides a continuous mixer for mixing incoming product streams to yield a final product stream of desired characteristics. Broadly speaking, the mixer includes an elongated housing having a plurality of inputs for receiving incoming product streams, as well as an output for the final product. A plurality (usually two) of elongated, side-by-side, axially rotatable mixing screws are located within the housing and extend along the length thereof in order to convey and mix the incoming streams and to move the final product out the housing output. Each of these mixing screws includes a series of outwardly projecting mixing elements each having a base and a plurality of converging sidewall surfaces, the latter cooperatively defining an outer end having a surface area less than the base surface area. These mixing elements are oriented along the length of the mixing screws, preferably in a helical pattern.

In preferred forms, the mixing screws are in intermeshing relationship and are designed to co-rotate, i.e., to rotate in the same direction; however, the screws can also be counter-rotating if desired. The screws preferably include input sections adjacent the housing product stream inputs and present helical flighting along the lengths thereof; the screws also have output sections extending from the ends of the input sections toward the housing output, with the outwardly projecting mixing elements being located on the output sections. The individual mixing elements are generally pyramidal in shape, presenting a base of generally diamond-shaped plan configuration with four outwardly extending, arcuate converging wall surfaces terminating in an apex-like outer end.

-3-

The housing is equipped with a plurality of injection ports spaced along the length thereof to permit injection of materials such as CO₂ into the housing during operation. In addition, the housing also a series of sensor ports along the length thereof to permit installation of temperature, pressure or other parameter sensors. In order to provide better temperature control, the housing has an outer shell and inner screw-receiving walls to define therebetween a passageway; cold water or other cooling media may be circulated through the passageway during operation of the mixer.

A particular (although not exclusive) utility of the mixer of the invention is for producing a comminuted meat product having a predetermined and substantially constant fat/lean ratio, using input meat streams of different fat/lean ratios respectively. To this end, the mixer is preferably used in an overall mixing system including a plurality of incoming product lines operably coupled with the mixer, where each of the product lines has a product source, a product pump and a product analyzer. In such a system, the pumps are operated to generate the incoming product streams, which are analyzed to determine a desired input characteristic thereof (such as fat/lean ratio). The operational speed of the individual product line pumps is then adjusted in response to analysis of the incoming product streams, thereby generating product streams having a desired input characteristic at a substantially constant magnitude for each incoming product stream. Once such constant characteristic streams are achieved the incoming product streams are directed to the mixer which is operated to create the final product stream. Preferably, this final product stream was again analyzed to determine a desired output characteristic thereof, followed by altering the operational speed of one or more of the product line pumps as necessary to maintain the desired output characteristic in the final product stream.

In another embodiment, each of the incoming product lines includes a combined preblender and pumping device in lieu of separate preblenders and pumps. Such a combined device preferably includes an upper hopper equipped with a pair of rotatable shafts having outwardly extending paddle elements. Also, the device includes a lower pumping section made up of side-by-side, fully intermeshed, rotatable auger screws which create the necessary pumping force to convey product from the combined device for downstream processing.

The preferred mixer is designed so as to mix incoming product streams and create a homogeneous output of substantially constant characteristics, without undue meat comminution or smear. In practice, the mixers of the invention are operated so as to limit meat temperature

-4-

to no greater than about 50°F, more preferably from about 20-40°F. Residence time in the mixers of the invention should range up to about 3 minutes, more preferably from about 1-2 minutes; pressure conditions within the mixer are essentially atmospheric, but the mixer may be operated at a slight positive pressure if desired.

5 While the system and continuous mixer of the invention are especially adapted for use in the meat industry, a number of variations are possible. For example, spices or liquid smoke may be injected into the continuous mixer to produce sausage-like products. Alternately, textured vegetable protein may be added to one or more of the meat streams, or the system can be used to mix a meat stream and a TVP stream, respectively. Finally, the mixer of the
10 invention, owing to its unique screw configuration, may be used for the processing of non-meat products such as cheeses, fruits and vegetables.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic flow diagram illustrating the preferred system of the invention for
15 homogeneously nixing a plurality of incoming product streams to yield a final product stream of desired characteristics;

Fig. 2 is a flow diagram of the preferred software algorithm used in the control of the system illustrated in Fig. 1;

Fig. 3 is an isometric view of the preferred continuous mixer forming a part of the system
20 of Fig. 1;

Fig. 4 is an isometric view similar to that of Fig. 3, but with certain parts broken away to reveal the internal construction of the mixer;

Fig. 5 is a plan view of the mixer depicted in Fig. 3;

Fig. 6 is an end view of the mixer shown in Fig 5, illustrating the output end of the mixer;

25 Fig. 7 is a sectional view taken along line 7-7 of Fig. 6;

Fig. 8 is a sectional view taken along line 8-8 of Fig. 5;

Fig. 9 is a plan view of a mixer screw section, depicting the generally pyramidal mixing elements forming a part of the preferred internal mixing screws of the continuous mixer;

Fig. 10 is an isometric view of the mixing screw section illustrated in Fig. 9.

30 Fig. 11 is an isometric view of a combined preblender and pump apparatus useful in the systems of the invention;

-5-

Fig. 12 is an elevational view of the apparatus depicted in Fig. 11;

Fig. 13 is a plan view of the Fig. 11 apparatus;

Fig. 14 is a front end view of the Fig. 11 apparatus;

Fig. 15 is a vertical sectional view taken along line 15-15 of Fig. 14 and illustrating the
5 internal construction of the combined apparatus;

Fig. 16 is a horizontal sectional view taken along line 16-16 of Fig. 12;

Fig. 17 is a vertical sectional view taken along line 17-17 of Fig. 12; and

Fig. 18 is a schematic representation of the continuous mixer of the invention, with a pair
of the combined preblender and pump devices coupled thereto.

10

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Turning now to the drawings, and particularly Fig. 1, a preferred system 20 is schematically illustrated for homogeneously mixing plural incoming product streams 22 and 24 to yield a desired final product stream 26. Broadly speaking, the system 20 includes a pair of
15 incoming product lines 28, 30 which are operatively coupled with a continuous mixer 32. The system 20 as shown is designed for processing first and second meat sources M1 and M2 having different fat/lean ratios in order to generate the final product stream 26 having a desired and predetermined fat/lean ratio.

In more detail, each of the product lines 28, 30 includes a grinder 33 and a preblender 34,
20 a product pump 36, and a fat content analyzer 38. The grinder/preblend equipment 33, 34 is essentially conventional and is designed to take an incoming meat source and generate a uniform ground meat output. Similarly, the pump 36 and analyzer 38 are conventional.

As also illustrated in Fig. 1, a fat content analyzer 40 is used to determine the fat content of the final product stream 26; to this end, the analyzer 40 is downstream of mixer 32 and
25 upstream of packaging equipment (not shown) used to package the final product. The output from analyzer 38 includes a three-way valve 39 with a recycle line 39a and a mixer conduit 39b.

Attention is next directed to Figs. 3-10 which illustrate in detail the preferred mixer 32. Broadly, the mixer 32 includes an elongated housing 42 with a pair of elongated, side-by-side,
30 axially rotatable, intermeshed mixing screws 44, 46 located within the housing and extending

-6-

along the length thereof; the screws 44, 46 are rotated by means of a conventional gear reduction drive 48 coupled to a motor (not shown).

The housing 42 includes an inlet head 49 having a pair of opposed, tubular inlet ports 50, 52 and end walls 54, 56, as well as an outlet head 60 presenting an end wall 62 and an elongated slot-like mixer output 64. As shown, the housing 42 also has two aligned head sections 66 and 68 between the inlet and outlet heads 49 and 60. The section 66 has a pair of circular end walls 70, 72; an outermost, elongated circular in cross-section shell wall 74 as well as an elongated, inner, screw-receiving wall 76 of somewhat "figure 8" configuration extend between and are supported by the walls 70, 72. Similarly, the section 68 has end walls 78, 80 supporting shell wall 82 and inner screw-receiving "figure 8" wall 84. As illustrated in Fig. 3 for example, the circular walls 72 and 78 are bolted together, with end wall 80 connected to reducer 48 and with end wall 70 coupled with wall 62 through an intermediate annular spacer 86; in this way, a housing 42 is provided with continuous inner screw-receiving walls.

The housing head sections 66 and 68 are each equipped with a series of injection ports 88 along the length thereof which permit attachment of injectors (not shown) for the selective injection of additives and/or coolants such as carbon dioxide. As best illustrated in Fig. 7, the ports 88 extend through the outer and inner housing walls to communicate with the interior of the housing. Also, the sections 66 and 68 have sensor mounts 90 along the length thereof for selective mounting and attachment of temperature or other type of sensors. In the use of mixer 32 as more fully described below, a liquid coolant may be passed through respective coolant passageways 92 and 94 provided between the outer and inner housing walls 74, 76 and 82, 84; to this end, the head sections 66 and 68 have appropriately sized and configured coolant entry ports 96 and corresponding outlet ports (not shown).

The screws 44, 46 are housed within and extend along the length of the housing 42. As shown in Fig. 8, the screws are positioned within the "figure 8" housing walls 76 and 84, and are operatively coupled to the drive 48 for rotation thereof. The screws include a respective elongated splined shafts 98, 100, which support corresponding inlet screws 102, 104 and downstream mixing screws 106, 108. The inlet screws each include continuous helical double flighting 110, 112 which serves to move material entering the mixer through the inlets 50, 52 toward outlet head 60.

-7-

The mixing screws 106, 108 are secured to the shafts 98, 100 and are of specialized configuration to mix the incoming products and produce a uniform output, without creation of undue shear conditions. Attention is directed to Figs. 9 and 10 which depict in detail the preferred configuration of the mixing screws. Specifically, each of the mixing screws has a series of outwardly projecting, abutting mixing elements 114, each presenting a base 116 and a plurality of converging sidewall surfaces 118, 120, 122, and 124 which terminate in an outer surface 126 having a surface area less than that of the base 116. The elements 114 are oriented in a dual helix pattern along the length of the screw section, leaving corresponding helical base surfaces 128 and 129 between the convolutions of the elements 114.

In more detail, each of the elements 114 is generally pyramidal in shape, with the corresponding base 116 generally diamond-shaped in plan configuration and presenting four arcuate surfaces 118-124 and the apex-like surface 126. Each diamond-shaped base 116 is defined by two pairs of substantially parallel marginal base surfaces, namely long surfaces 130, 132 and short surfaces 134, 136. As best seen in Fig. 9, the long base surfaces 130 of the elements 114 lie along a first helical line 138 whereas the opposed long base surfaces 132 lie along a second helical line 140, with the helical lines 138, 140 being of substantially equal pitch. In addition, the short base surfaces 134 cooperatively define a third helical line 142, with the opposed short base surfaces 136 defining a fourth helical line 144. Again, the helical lines 142, 144 are parallel to each other, and have substantially the same pitch. However, the pitch of the long base surface helical lines 138, 140 is greater than the pitch of the short base surface helical lines 142 and 144. It will also be seen that the outwardly extending surfaces of the elements 114 lie in and cooperatively define respective helical surfaces.

The mixing screws 106, 108 are preferably manufactured by first creating a screw with conventional double helix flighting having the larger pitch referred to previously. Thereafter, this screw is cut to present double helix reverse flighting having the smaller pitch mentioned above. This manufacturing procedure creates the series of mixing elements 114.

In the operation of mixer 32, incoming products are directed through the ports 50, 52 into the interior of the housing 42. At the same time, the screws 44, 46 are rotated so as to move the products towards outlet opening 64. During traversal of the inlet sections 102 and 104, only a minor amount of mixing occurs. However, as the products enter and pass along the length of the mixing screws 106, 108, the product is very intensely mixed so as to yield a final product

-8-

stream 26 of uniform characteristics. A significant advantage of the mixer 32 is that such product stream mixing is obtained without substantial heating of the products or generation of shear. This effect is achieved by the geometry of the helically arranged mixing elements 114 which serve to not only move the product toward the outlet 64, but also impart a significant amount of flow reversal to the products. Of course, the net movement of the products within the housing is from the inlet ports to the outlet; nevertheless, during such movement there is significant flow reversal so as to obtain the desired homogeneous final product stream.

During the course of mixing, it may be desirable to pass thermal fluid (e.g., cold water or a heating media to inhibit fat buildup) through the passageways 92 and 94 so as to indirectly cool the products. Also, carbon dioxide may be injected through some or all of the ports 88 for this purpose. Process control is facilitated by means of the mounts 90, allowing temperature probes or the like to be mounted along the length of the mixer.

In preferred forms, the system 20 is designed for creating an output stream 26 of predetermined and substantially constant fat/lean ratio, using two individual meat sources M1 and M2 of different fat/lean ratios. Moreover, the system 20 is advantageously configured for computer control. That is, the components of the system 20, including the grind/preblend devices 33, 34, pumps 36, mixer 32 and fat content analyzers 38 and 40 are appropriately connected to a microprocessor (not shown). Additionally, all of the components of the system 20 are usually provided with CO₂ injection apparatus so as to maintain, to the extent feasible, the meat being processed under oxygen-free or at least oxygen-minimized conditions.

Fig. 2 depicts a suitable control program useful in the context of the invention. In particular, in the first steps 146 and 148, an initial speed for the pumps 36 is calculated. This involves inputting into the control program fat/lean ratio estimates for the respective meat streams, the desired fat/lean ratio of the output stream 26, and the desired final output rate. Also, fat and lean meat densities values, as well as pump volumes per cycle of the pumps 36 is retrieved from the computer memory. This information is used step 148 to calculate the initial pump speed for each of the pumps 36.

In the next step 150, the program initiates operation of the grinders and preblenders 33, 34., and also begins the operation of the pumps 36 at the initially calculated speed (step 151). After an appropriate data acquisition delay (e.g., 10 seconds), the fat content in the respective

streams is measured in step 152. Such measurements are taken repeatedly, and the measured fat data obtained during each measurement cycle are stored in computer memory.

The program next determines in step 154 whether the fat/lean ratios of the respective streams are within predetermined limits, such as $\pm 2\%$. If this stability has not been achieved, then the program proceeds to step 156 wherein the valves 39 are diverted to recycle the respective meat streams back to the preblenders 34 via lines 39a, and the process of steps 152-156 is repeated, using the newly calculated pump speeds.. Once the stability requirement of step 154 is met, the program proceeds to step 158 where the operation of the mixer 32 is commenced at a preset speed correlated with the desired final output rate. Mixer operation may also involve circulation of a thermal fluid through the ports 96 and the corresponding outlets, and/or injection of coolant or other additives through the injection ports 88. Also, in step 160, both meat streams are diverted to mixer 32 by appropriate operation of the valves 39.

In step 162, the previously measured and stored fat content data for the meat products at and about to enter the continuous mixer inlets is retrieved, and the pump speeds are recalculated; as necessary, these pump speeds are changed in step 164.

As mixed product emerges from mixer outlet 64, the fat content thereof is measured in analyzer 40, as set forth in step 164. This permits a calculation (step 166) of which line 22 or 24 would benefit most from correction of pump speed. That is, it is desirable to operate the pumps 136 as close as possible to the middle of the operating range of the pumps. Accordingly, in step 168, appropriate correction factors are used to adjust the speed of the pumps 36. In this way, stable running conditions can be achieved and maintained throughout the course of a given run. By the same token, if the characteristics of either or both of the meat sources M1 and M2 change, this change can be accommodated within practical limits to maintain consistency in the final product.

Turning to Fig. 18, a system 200 is schematically illustrated for homogeneously mixing plural incoming product streams of meat or the like to yield a final output stream of desired characteristics. The system 200 is similar in many respects to that illustrated in Fig. 1. However, in this instance, the system is considerably simplified through the use of a pair of combined preblender and pumping devices 202 in lieu of the preblenders 34, pumps 36 and related equipment. In particular, the system 200 again makes use of separate incoming product lines 204, 206 which are designed to handle the divergent incoming product streams. Each line 204,

-10-

206 includes, for meat handling operations, a grinder 208 directly coupled to and feeding the devices 202. The output from the latter passes through a fat analyzer 210 and thence into the continuous mixer 32. The system downstream of the mixer 32 is substantially identical to that described with reference to system 20 of Fig. 1.

5 Broadly speaking, the combined preblender and pump device 202 includes an open top hopper preblend section 212 with a lower, twin-screw feeder-pump unit 214. In the embodiment shown, the unit 214 is equipped with a transition 216 adapted for coupling directly to the input of fat analyzer 210.

10 The upper preblend section 212 includes an elongated hopper 218 defined by arcuate sidewalls 220, 222, forward end 224 and rear end wall 226. The sidewalls 220, 222 merge to form a bottom wall 228 which extends from rear end wall 226 forwardly, but has, adjacent the forward end thereof, an outlet section 230 made up of vertical end wall 232 and side margins 234, 236. Thus, an outlet opening 237 is defined between the wall 232, margins 234, 236 and front end wall 224. Although not shown, the hopper 218 is provided with a top wall covering
15 the upper end of the hopper in a substantially air tight fashion. As illustrated, the hopper 218 is supported on an upright frame 238 to assume an elevated position.

 The hopper 218 is equipped with a pair of elongated, fore and aft extending, axially rotatable mixing shafts 240, 242 which are conventionally powered by a motor (not shown). As best seen in Fig. 13, the shafts 240, 242 are each equipped with a plurality of outwardly
20 extending, elongated, staggered paddle elements 244. The latter are oriented so as to permit free rotation of the shafts 240, 242; however, at the mid-section of the hopper 218, the elements 244 are intercalated. The respective paddle elements 244 are designed to preblend incoming product into the hopper 218, and to move such material forwardly towards and into outlet section 230. The rear end wall 226 is equipped with a tubular product input 246 which is designed to be
25 connected with the output of a grinder 208, again in a substantially air tight manner.

 The feeder pump unit 214 includes an elongated housing 248 secured to the underside of hopper 218 and extending forwardly therefrom. The housing 248 has a pair of side-by-side, communicating arcuate sections 250, 252 with an elongated rearward opening therein which mates with and forms a continuation of outlet opening 237. A pair of elongated, axially flights
30 auger screws 254, 256 are located within housing 248 and extend along the length thereof. As best seen in Fig. 16, the screws 254, 256 include rearward mixing sections 258, 260 designed to

-11-

mix product from hopper 212, as well as forward pumping sections 262, 264. The pumping sections are single flight (although multiple flights could be used) fully intermeshed screw sections designed to create a positive pumping force to propel preblended product towards the outlet of device 202. Preferably, the screws 254, 256 are counterrotating, but co-rotating designs could also be used. The screws 254, 256 are rotated by means of a conventional motor and gear reducer drive (not shown).

The forward end of housing 248 is equipped with a transition 266 which is in the form of a rectangular block having a converging internal passageway 268 and a substantially flat output face 270. The purpose of transition 266 is to direct product pumped via the unit 214 into the inlet of fat analyzer 210, and to also move product through the fat analyzer and into continuous mixer 32.

In the use of the devices 202, meat or other product to be processed is delivered from the grinder 208 through input 246 and directly into hopper 218. If desired, the grinder 208 and the device 202 are pressurized with carbon dioxide in order to minimize oxidation of the product during processing. Once the product enters hopper 218, it is immediately subjected to mixing by rotation of the shafts 240, 242 and the consequent action of paddle elements 244. The product moves forwardly from input 246 and progressively passes into and through opening 237 whereupon the product enters the housing 248. Additional mixing is carried out in the rearward section of the housing 248, at the area of screw sections 258, 260. As the product advances along the length of these mixing screw sections, it next encounters the pumping screw sections 262, 264. Owing to the fully intermeshed construction of the sections 262, 264, the product is forced along the remaining length of the housing 248 and thence into and through transition 266, analyzer 210 and into continuous mixer 32. The mixer 32 operates in the same manner described previously with reference to system 20 in order to generate a final product stream 26 which is fat-analyzed and packaged.

The system 200 using the combined preblender and pump devices 202 can be controlled using software analogous to that described with reference to Fig. 2. Those skilled in the art will appreciate that certain changes would be made in the control software as compared with that shown in Fig. 2, but these are within the skill of the art.

-12-

A principal advantage obtained through use of the system 200 is the elimination of separate preblenders and pumps, and the associated connection hardware and control elements. Thus, the system 200 can be more economically produced and operated.

-13-

We claim:

1. A continuous mixer for mixing incoming product streams to yield a final product stream of desired characteristics, said mixer comprising:

an elongated housing having a plurality of inputs for receiving said incoming product streams, and an output for said final product; and

a plurality of elongated, side-by-side, axially rotatable mixing screws located within said housing and extending along the length thereof for conveying and mixing said incoming product streams and for moving said final product out said output,

at least a pair of said mixing screws having a central section and a series of mixing elements projecting outwardly from said central section, said mixing elements each having a base and a plurality of converging sidewall surfaces extending outwardly from said base to present an outer end having a surface area less than the surface area of the base,

at least certain of said elements being located along at least a portion of said central section.

2. The mixer of claim 1, said mixing elements being oriented in a helical pattern.

3. The mixer of claim 2, each of said screws having an input section adjacent said inputs and presenting helical flighting along the length thereof, and an output section extending from the end of said input section toward said housing output, said mixing elements being located on said output section.

4. The mixer of claim 3, the flighting of said input sections being intermeshed, and the mixing elements of the output sections of said screws also being intermeshed.

-14-

5. The mixer of claim 2, each of said mixing elements being generally pyramidal in shape, presenting a base which is generally diamond-shaped in plan configuration with four outwardly extending and converging sidewall surfaces terminating in a apex-like outer end.

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6. The mixer of claim 5, the diamond-shaped base having two pairs of substantially parallel base surfaces, one of said base surface pairs having a length greater than the other of said base surface pairs.

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7. The mixer of claim 6, the base surfaces of said one surface pairs lying along respective, parallel first helices of a first, substantially equal pitch, and the base surfaces of said other surface pairs lying along respective, parallel, second helices of a second, substantially equal pitch, said second pitch being smaller than said first pitch.

15

8. The mixer of claim 1, said housing including a plurality of injection ports spaced along the length thereof to permit injection of materials into the housing during operation of the mixer.

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9. The mixer of claim 1, said housing having a series of sensor ports spaced along the length thereof to permit installation of one or more sensors.

10. The mixer of claim 1, said housing including an outer shell and an inner housing wall to cooperatively define a passageway therebetween, there being an inlet and an outlet in communication with said passageway.

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11. The mixer of claim 1, there being a pair of said inputs located in opposed relationship adjacent one end of said housing.

-15-

12. A screw set for a mixer, comprising:

5 a pair of elongated, side-by-side, axially rotatable mixing screws each having a central section and a series of mixing elements projecting outwardly from said central section, said mixing elements each having a base and a plurality of converging sidewall surfaces extending outwardly from said base to present an outer end having a surface area less than the surface area of the base,
at least certain of said elements being oriented in a helical pattern along at least a portion of said central section.

10 13. The screw set of claim 12, each of said screws having an input section adjacent said inputs and presenting helical flighting along the length thereof, and an output section extending from the end of said input section, said mixing elements being located on said output section.

15 14. The screw set of claim 13, the flighting of said input sections, of said screws being intermeshed, and the mixing elements of the output sections of said screws also being intermeshed.

20 15. The screw set of claim 12, each of said mixing elements being generally pyramidal in shape, presenting a base which is generally diamond-shaped in plan configuration with four outwardly extending and converging sidewall surfaces terminating in a apex-like outer end.

25 16. The screw set of claim 13, the diamond-shaped base having two pairs of substantially parallel base surfaces, one of said base surface pairs having a length greater than the other of said base surface pairs.

-16-

17. The screw set of claim 16, the base surfaces of said one surface pairs lying along respective, parallel first helices of a first, substantially equal pitch, and the base surfaces of said other surface pairs lying along respective, parallel, second helices of a second, substantially equal pitch, said second pitch being smaller than said first pitch.

5

18. A method of mixing incoming product streams to yield a final product stream, said method comprising the steps of:

providing a mixer in accordance with claim 1;

passing a plurality of incoming product streams into said housing through said inputs;

10

rotating said mixing screws in order to convey and mix said incoming product streams along the length of said housing, and for moving final product out said housing output.

19. The method of claim 18, said incoming product streams comprising meat products of different fat/lean ratios.

15

20. The method of claim 18, including the step of injecting a coolant into said housing during rotation of said mixing screws.

20

21. The method of claim 18, including the step of measuring the temperature within said housing during passage of said incoming product streams therethrough.

22. The method of claim 18, including the step of passing an external coolant around said housing for indirectly cooling the product therein.

25

-17-

23. A method of controlling a mixing system designed to receive incoming product streams of different characteristics to yield a final product stream, said system including a plurality of incoming product lines each operably coupled with a continuous mixer, each of said incoming product lines including an incoming product source, a product pump and an incoming product analyzer, said method comprising the steps of:

operating said product line pumps to generate said incoming product streams;
analyzing each of said incoming product streams to determine a desired input characteristic thereof;

adjusting the operational speed of said pumps in response to said analyzing steps to create respective incoming product streams having said desired input characteristic at a substantially constant magnitude for each incoming product stream;
after said adjusting step, directing said incoming product streams to said mixer, and operating the mixer to create a final product stream;

analyzing said final product stream to determine a desired output characteristic thereof;
and

altering the operational speed of one or more of said pumps as necessary to achieve and maintain said desired output characteristic in said final product stream, in response to said final product analysis step.

24. The method of claim 23, each of said incoming product streams comprising meat.

25. The method of claim 24, said desired input characteristic of said incoming product streams being the fat/lean ratio thereof.

26. The method of claim 23, the desired output characteristic of said final product stream being the fat/lean ratio thereof.

-18-

27. A system for receiving and handling incoming product streams of different characteristics to yield a final product stream, said systems comprising:

a incoming product line for each of said streams respectively, each of said lines including
a combined preblender and pumping device operable to receive, preblend and
5 pump the respective product stream into and through an output;
a continuous mixer operably coupled with the combined devices of each said product
lines in order to receive said product streams of said outputs, into generate said
final product stream.

10 28. The system of claim 27, said combined preblender and pumping device
comprising:

a hopper having an inlet and a spaced outlet;
a pair of elongated, axially rotatable shafts located within said housing, each of said
shafts having a plurality of outwardly extending mixing elements coupled thereto;
15 and
a pumping assembly including an elongated housing presenting an input and an output,
said housing input operably coupled with said hopper outlet, and a pair of
elongated, axially rotatable, flighted auger screws within said housing an operable
to pump said product through and out of said housing.

20 29. The system of claim 28, said auger screws being counter-rotating, fully
intermeshed screws.

-19-

30. A combined blending and pumping apparatus comprising:

a hopper having an inlet and a spaced outlet;

a pair of elongated, axially rotatable shafts located within said housing, each of said shafts having a plurality of outwardly extending mixing elements coupled thereto;

5 and

a pumping assembly including an elongated housing presenting an input and an output, said housing input operably coupled with said hopper outlet, and a pair of elongated, axially rotatable, flighted auger screws within said housing an operable to pump said product through and out of said housing.

10

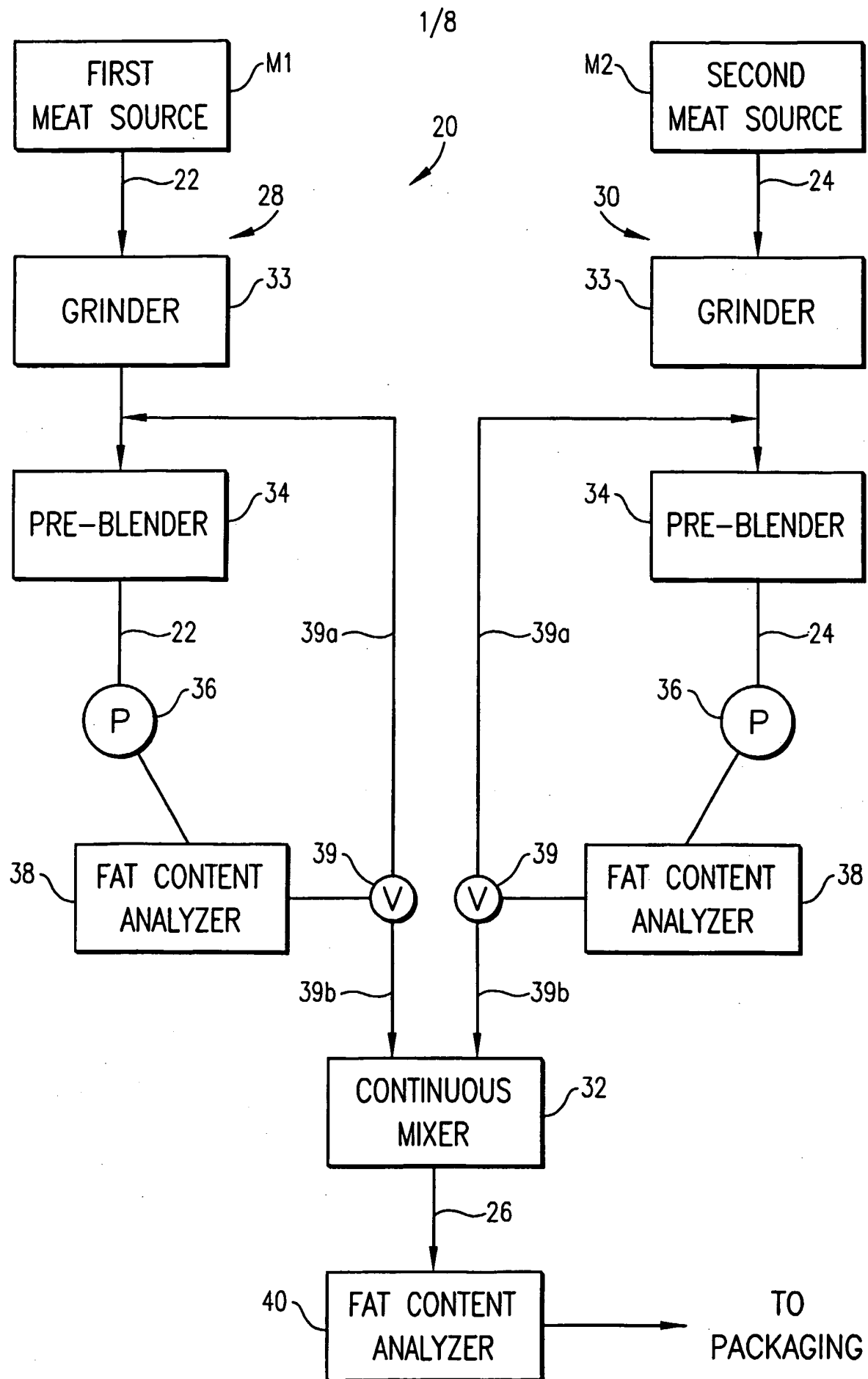


FIG. 1

2/8

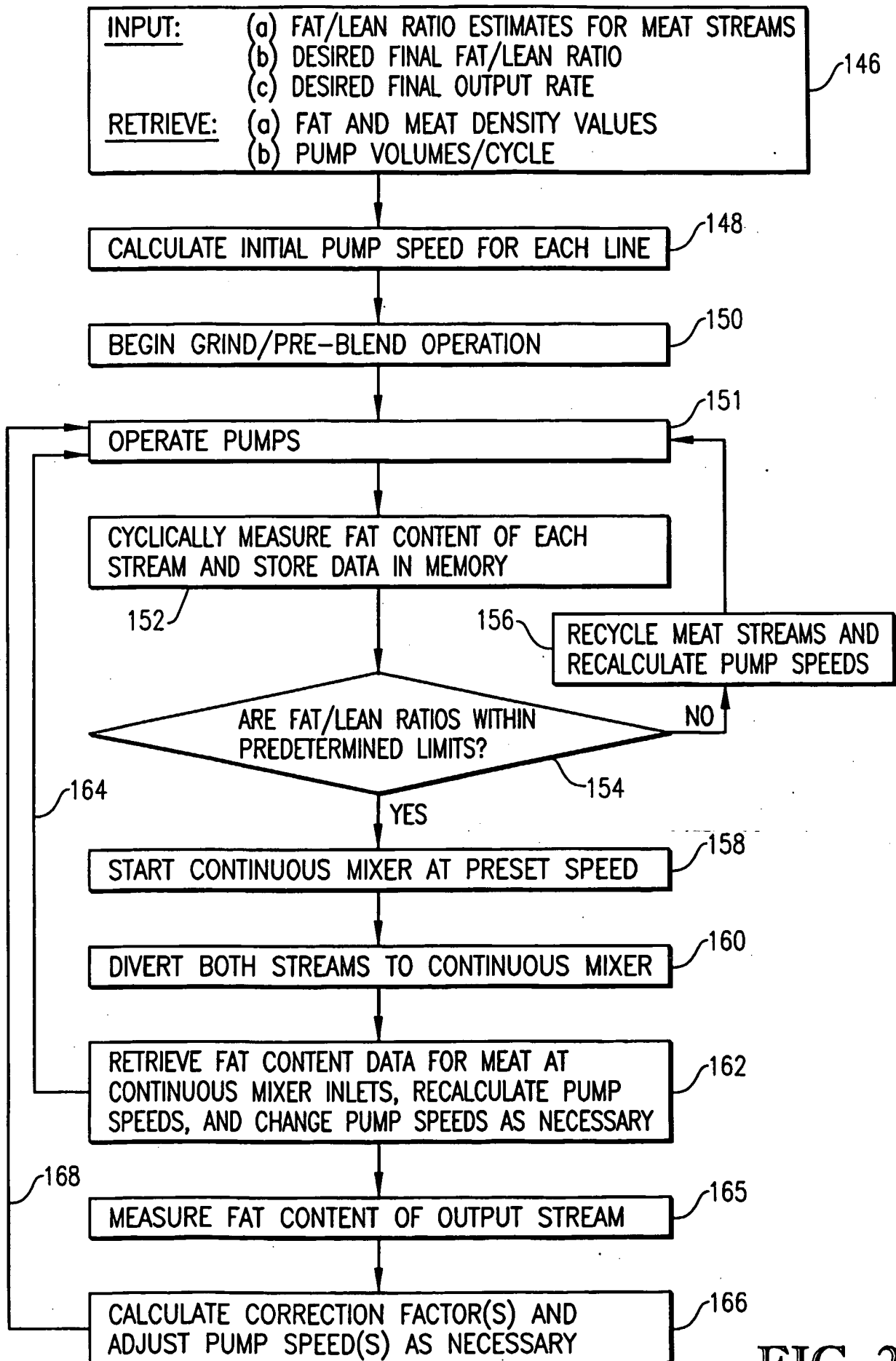
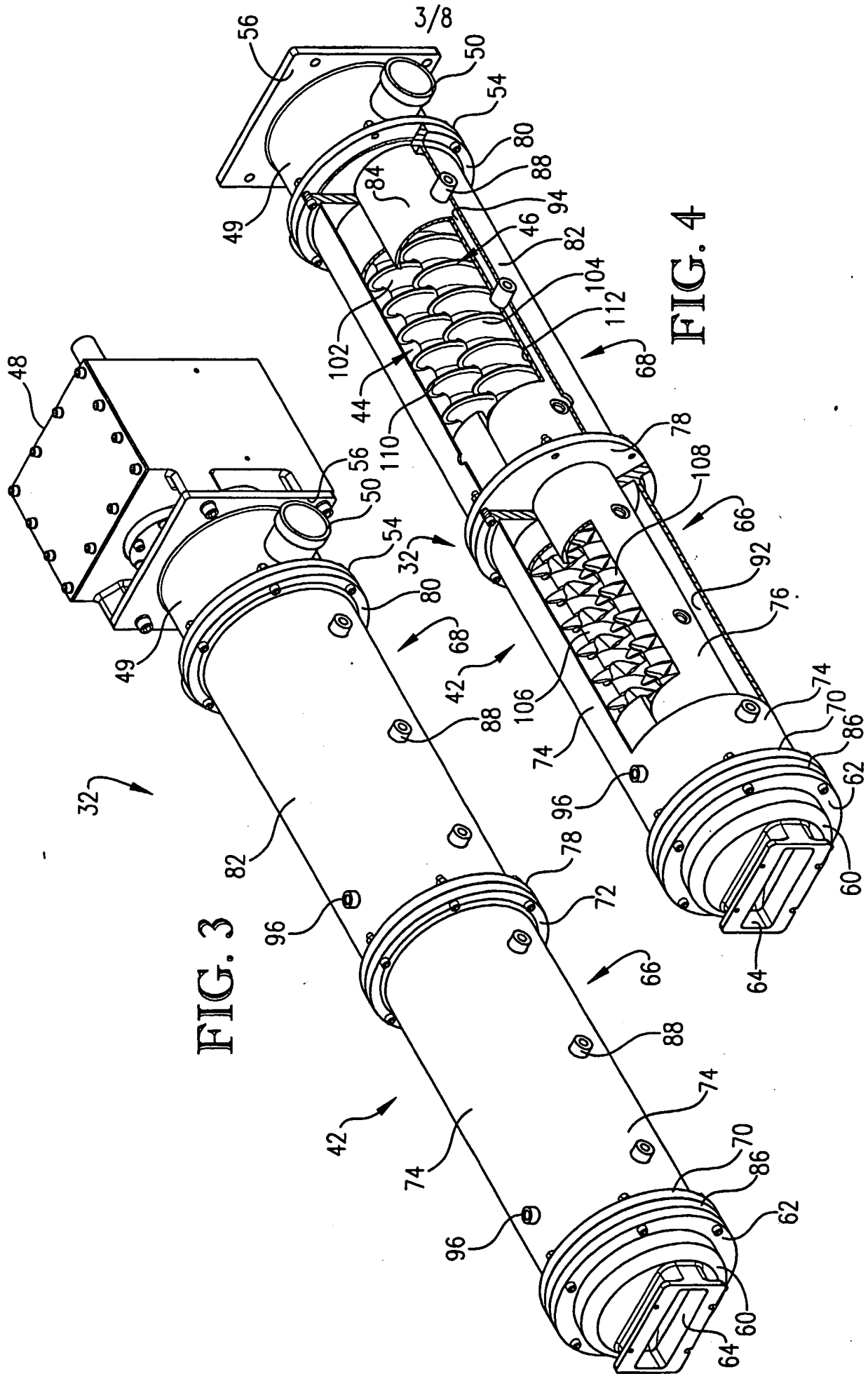
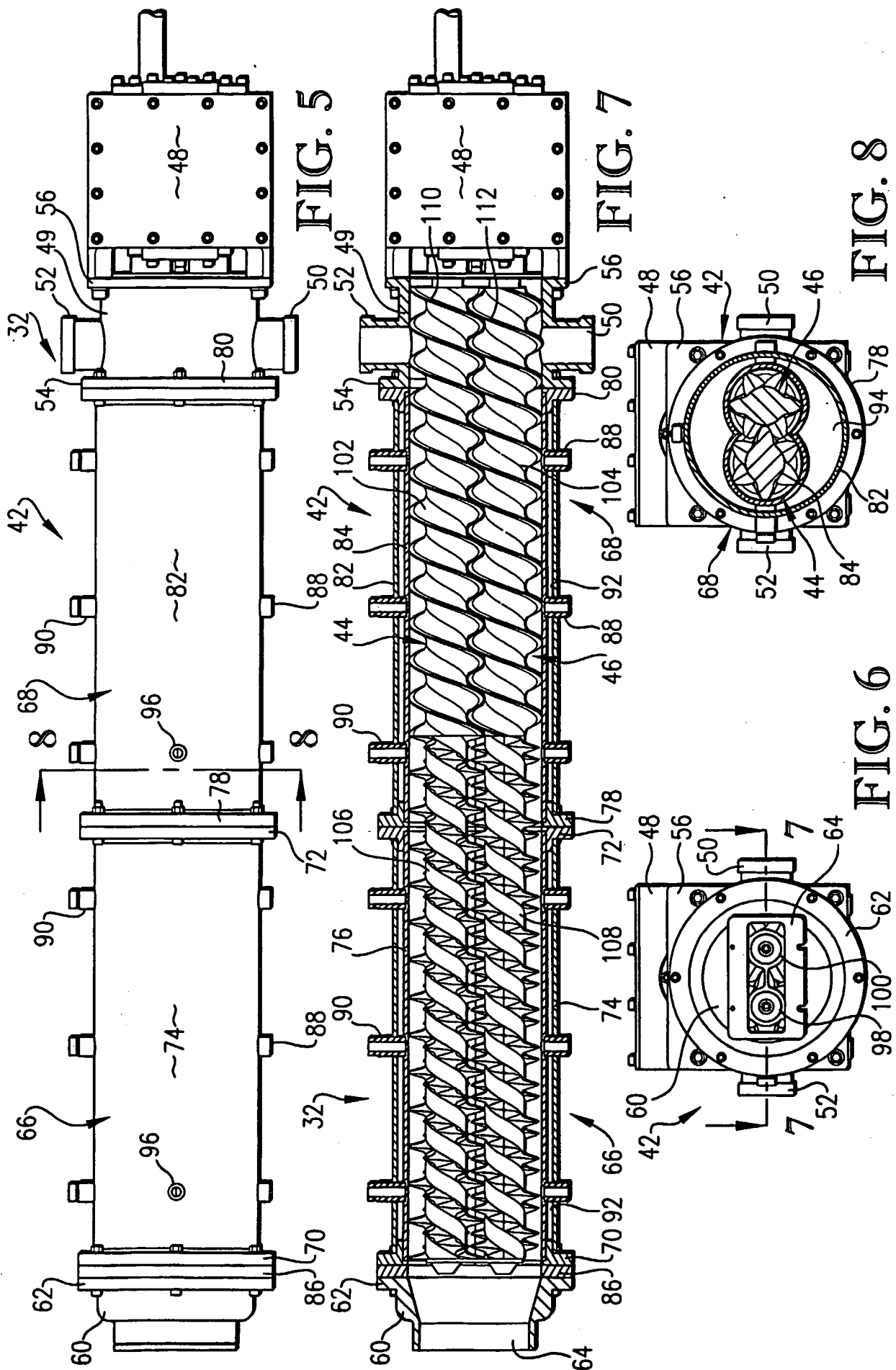


FIG. 2





5/8

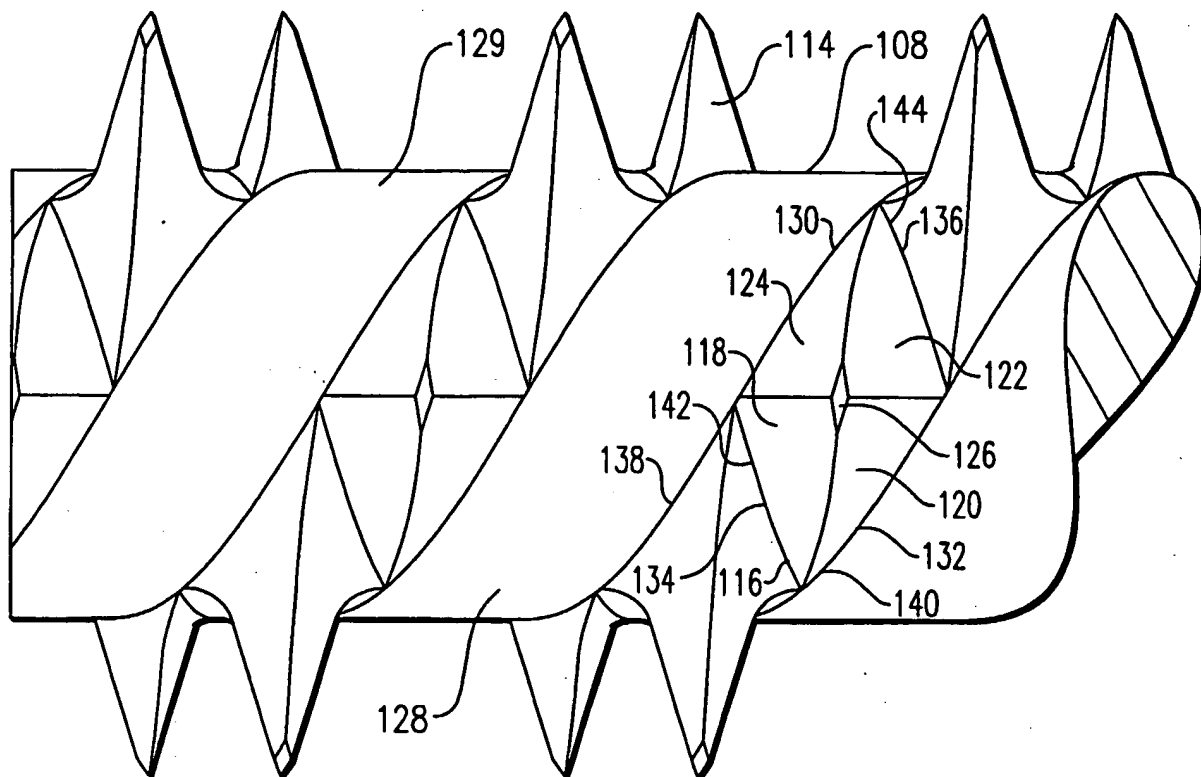


FIG. 9

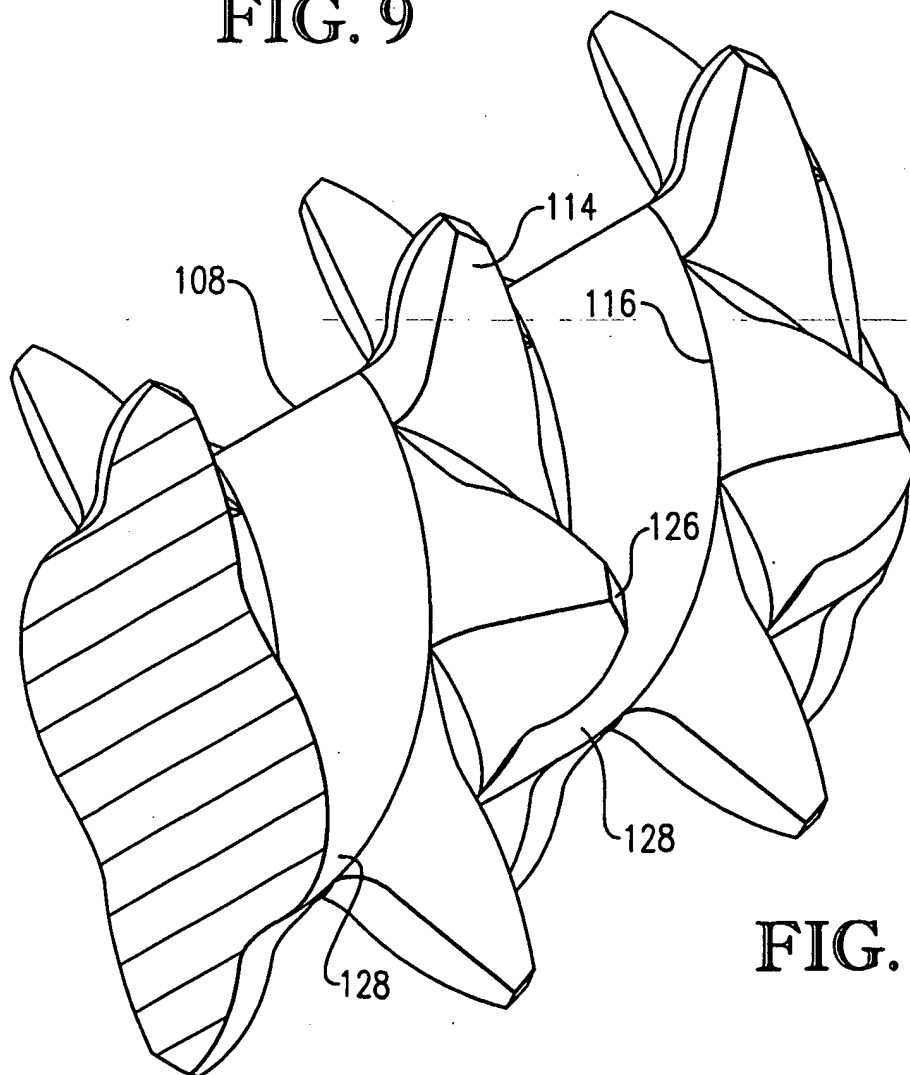


FIG. 10

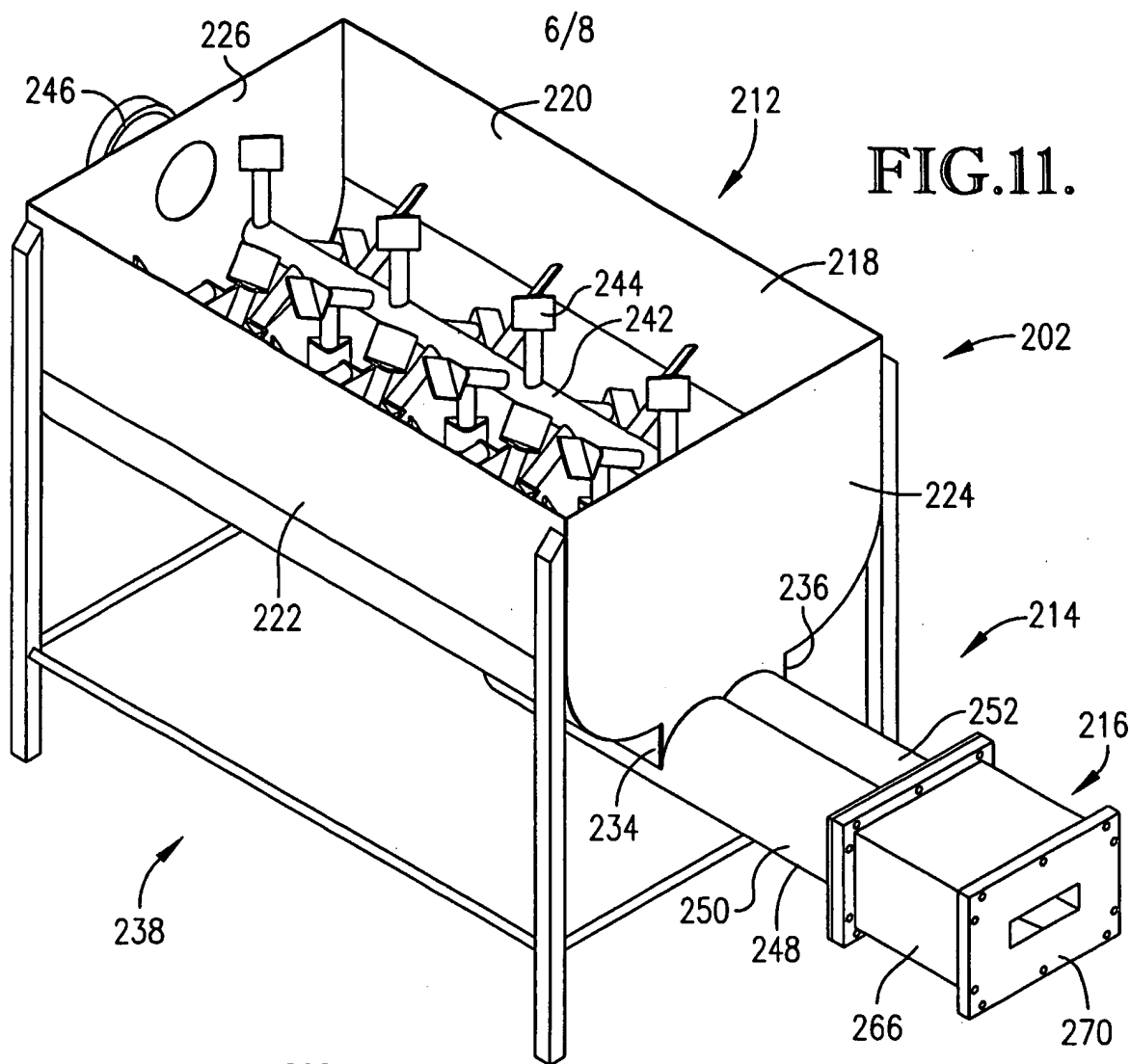


FIG. 11.

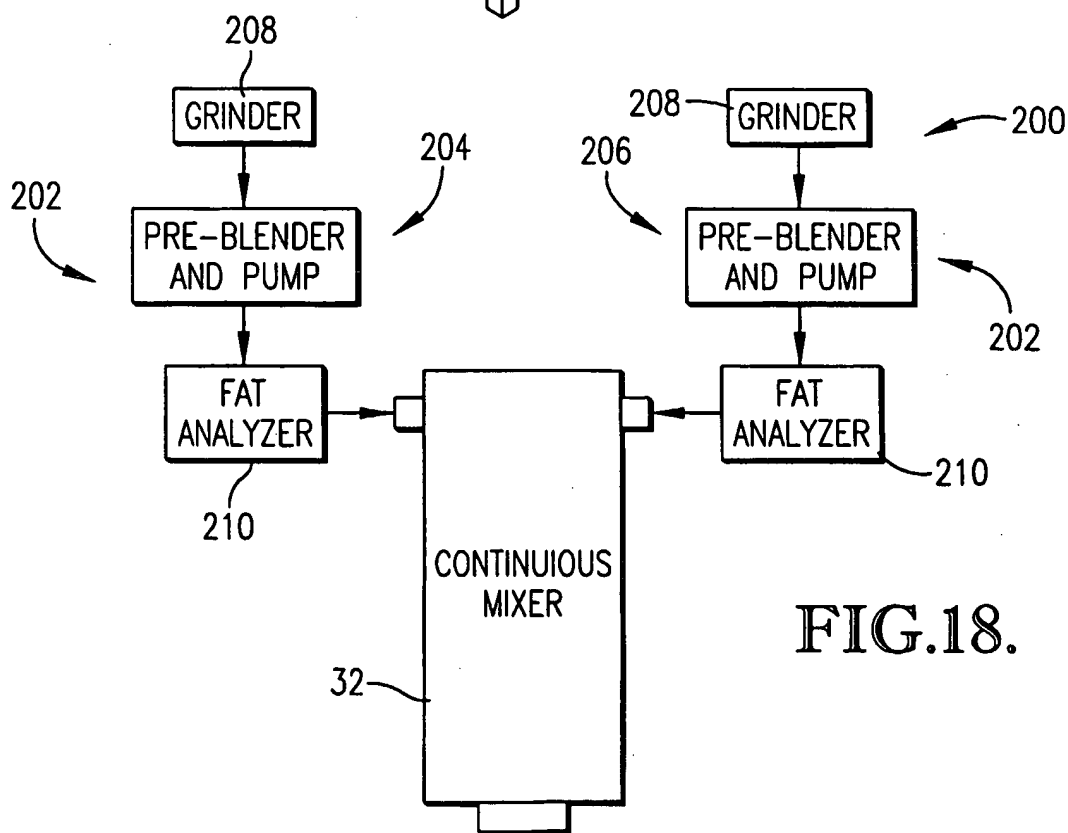


FIG. 18.

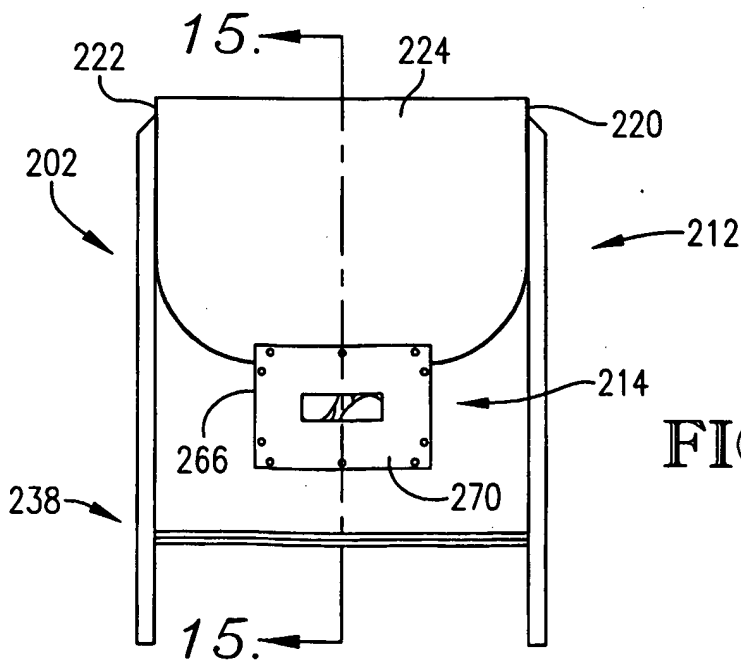
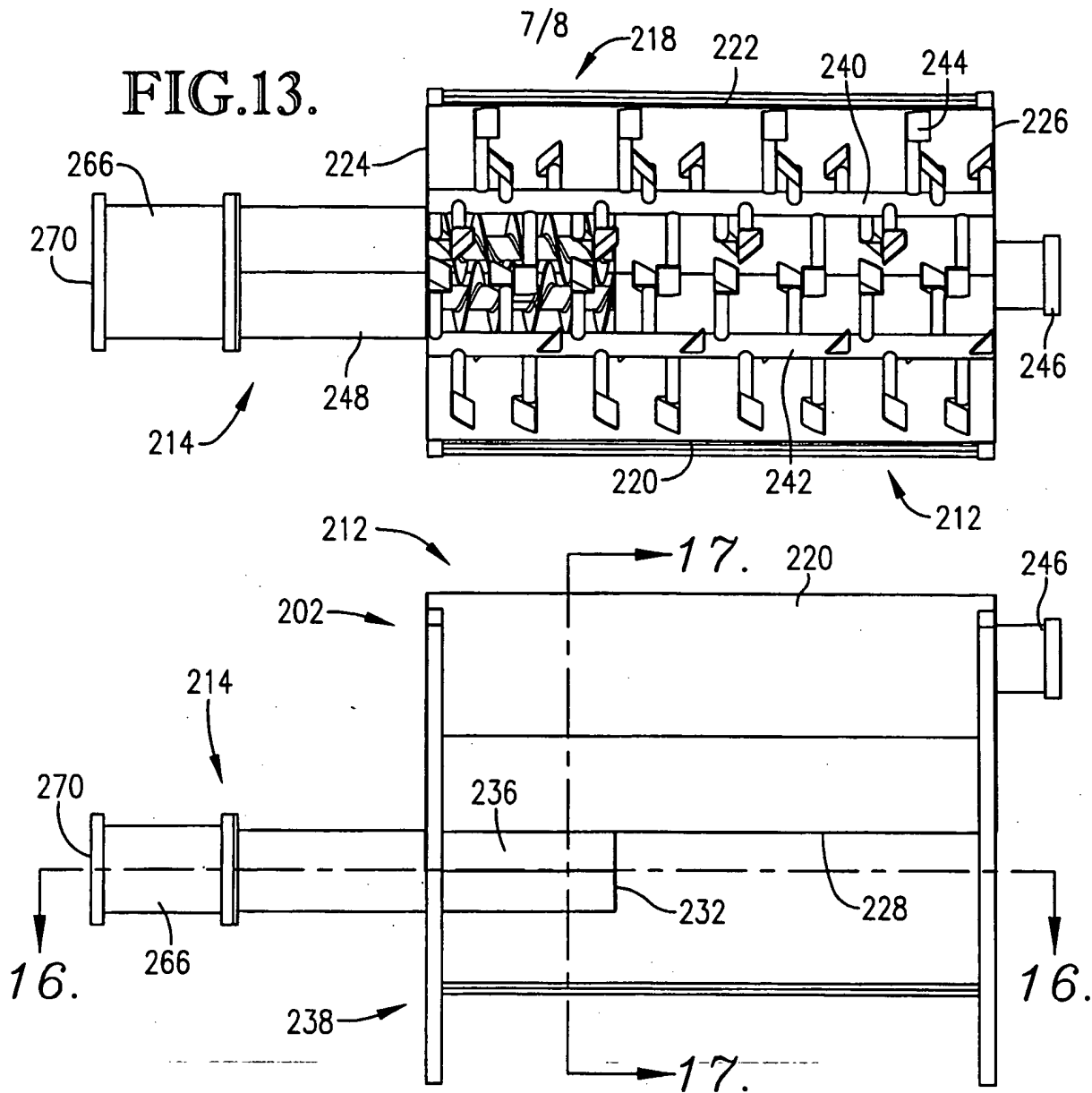


FIG.14.

8/8

FIG.16.

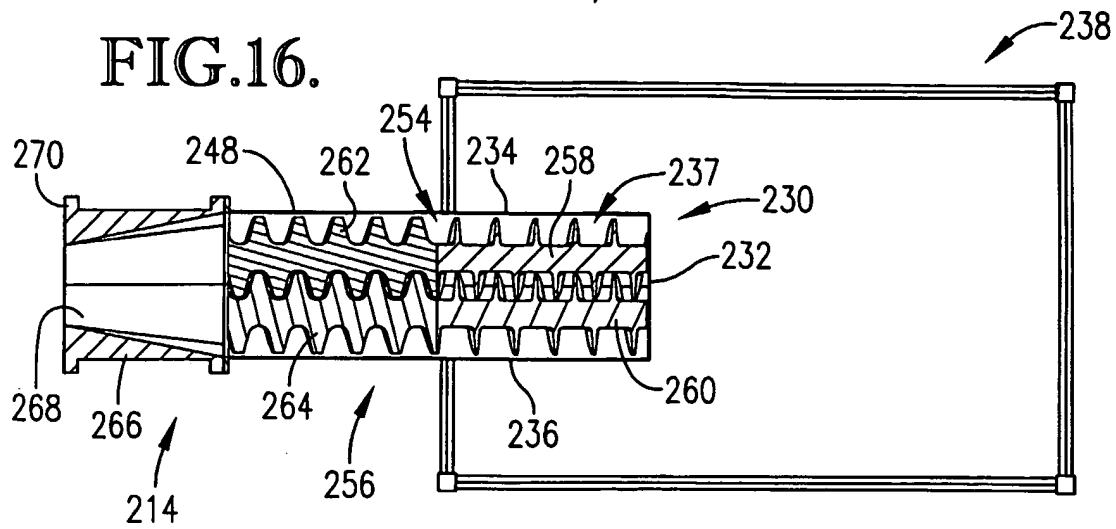


FIG.15.

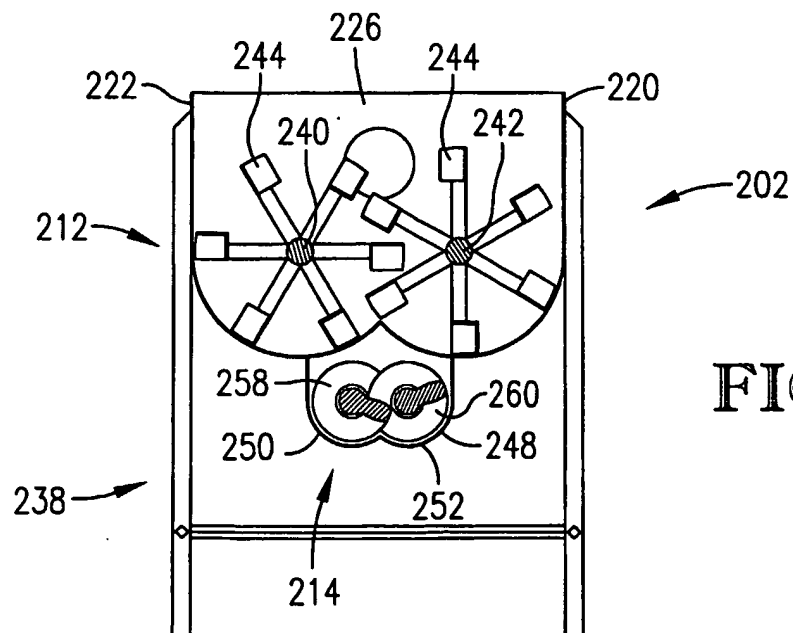
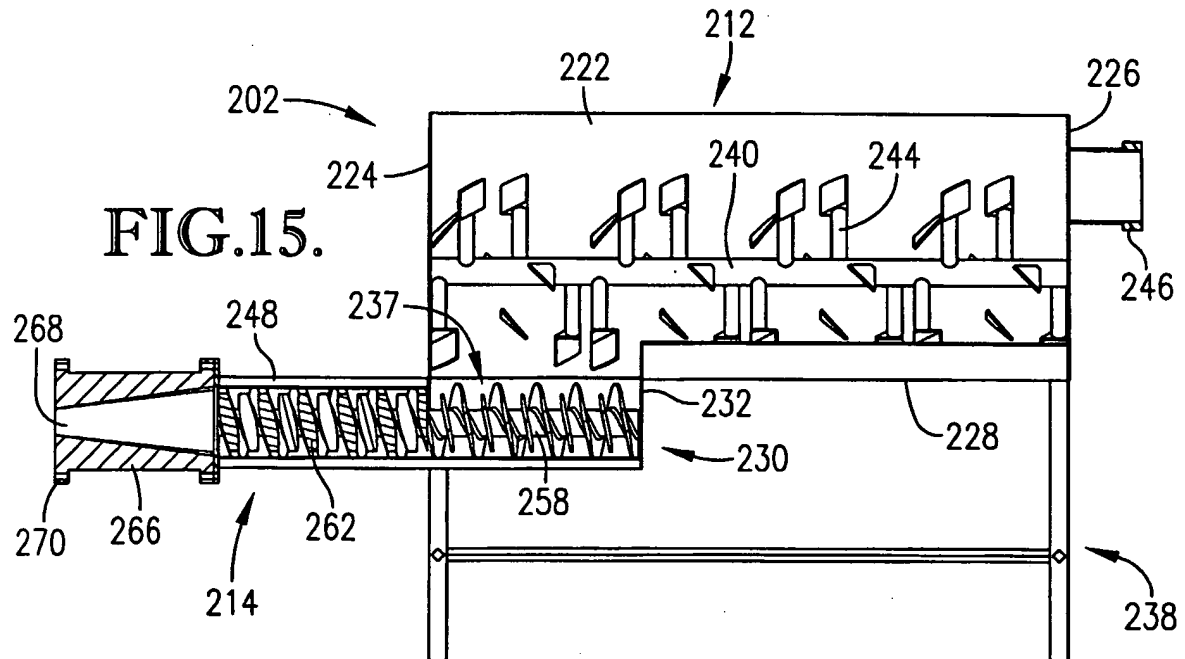


FIG.17.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US01/45827

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : B01F 7/08, 15/02

US CL : Please See Extra Sheet.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : Please See Extra Sheet.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
~~NONE~~

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EAST text search: pyramid\$ or conical

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,318,358 A (WOBBE et al.) 07 June 1994, see Figs. 1-4.	1-4, 12-14, 18
Y	US 5,358,693 A (BRINKMANN et al.) 25 October 1994, see Fig. 1.	8
Y	JP 4-20630 A (KONICA Corp.) 28 July 1992, see Figs. 1-2 and the abstract.	8
Y	US 5,324,108 A (BAUMGARTEN) 28 June 1994, see Fig. 8 and col. 4, lines 3-4 and col. 5, lines 50-53.	9
Y	US 4,508,454 A (ANDERS) 02 April 1985, see Figs. 1, 2, and 4 and col. 2, lines 59-63.	9

☒ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier document published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"A" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search
18 MARCH 2002

Date of mailing of the international search report
29 APR 2002

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US01/45827

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,800,055 A (SATO) 01 September 1998, see Figs. 3 and 9 and col. 5, line 66 through col. 6, line 29 and col. 8, lines 26-50.	10, 21, 22
Y	US 3,924,836 A (BRUNING et al.) 09 December 1975, see Figs. 1-3.	11
Y	US 3,014,437 A (DUTCHESS) 26 December 1961, see Figs. 1-2.	11
Y	US 4,476,686 A (MADSEN et al.) 16 October 1984, see Fig. 1 and the abstract.	20
Y	US 4,314,451 A (LEEDS et al.) 09 February 1982, see Fig. 1 and the abstract.	20
X	US 4,201,484 A (SASIELA et al.) 06 May 1980, see Figs. 1-8.	27
X	US 3,920,223 A (KRUEGER) 18 November 1975, see Figs. 1-5.	27
X	US Re. 34,172 A (GWINN et al.) 02 February 1993, see Figs. 1-2.	27
X	US 4,473,299 A (GUIBERT) 25 September 1984, see Fig. 1.	27
X	US 5,913,602 A (STEELE) 22 June 1999, see Figs. 1-2.	27
X	US 2,991,870 A (GRIFFITH et al.) 11 July 1961, see Figs. 1-3.	30
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Y		28
X	US 5,494,351 A (HAKASALO) 27 February 1996, see Figs. 1-3.	30
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Y		28-29
A	US 6,099,159 A (YOSHIDA et al.) 08 August 2000, see Fig. 3.	1-22
A	US 5,433,968 A (ZARRAGA et al.) 18 July 1995, see the Figure.	23-26

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US01/45827

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐
☐

The additional search fees were accompanied by the applicant's protest.

No protest accompanied the payment of additional search fees.

A. CLASSIFICATION OF SUBJECT MATTER:

US CL :

366/147, 149, 152.1, 159.1, 160.3, 186, 301, 319, 322; 426/231, 519

B. FIELDS SEARCHED

Minimum documentation searched

Classification System: U.S.

366/51, 76.1, 76.3, 76.4, 76.6, 77, 80, 81, 90, 91, 145, 147, 149, 152.1, 154.1-156.2, 158.1-158.4, 159.1, 160.3, 177.1, 186, 290-291, 301, 318, 319, 322, 325.3; 241/82.1, 101.2, 101.6, 101.8; 198/676; 426/231, 519

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING

This ISA found multiple inventions as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I, claims 1-22, drawn to a mixer and a screw set.

Group II, claims 23-26, drawn to a method of controlling a mixing system.

Group III, claims 27-30, drawn to a mixing apparatus with a blender and pumping device.

The inventions listed as Groups I, II, and III do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

In particular, Group I lacks adjusting the operational speed of pumps in response to analyzing by a product analyzer of Group II and lacks the preblender and pumping device of Group III; Groups II and III lack the mixing screws with mixing elements having a base and a plurality of converging sidewall surfaces extending outwardly from the base of Group I; and Group III lacks adjusting the operational speed of pumps in response to analyzing by a product analyzer of Group II and neither Group I or Group III can be used to perform the method of Group II.